DEVELOPING AND TESTING THE EFFECTIVENESS OF REMEDIAL TEACHING MATERIAL BASED ON CONCEPT FORMATION IN CHEMISTRY AT THE SECONDARY LEVEL

A

SYNOPSIS

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1.0.0 INTRODUCTION

Science is the process of diligence, refined over the years, by which we observe things as they are and events as they happen. It strives to be precise and accurate. Teachers play a significant role in each student's learning process. According to Driver (1986) the learning experiences provided by the teacher influences the quality of student's learning. The main objective of learning science is to provide a systematic, practical and interdisciplinary overview of the discipline and to change student behavior through his knowledge. Chemistry education involves a highly analytical and imaginative exercise moving from concrete macro-experience to highly micro components from facts to daring guesses and back to facts, from ordinary deductive and inductive logic to probabilistic statistics. All this has to take place in the school stage itself. Chemistry is often regarded as a difficult subject, an observation which sometimes repels learners from continuing with studies in chemistry. The field of chemistry is wide, its fund of facts, concepts that theories are constantly growing. The content that can be accumulated by rote is very limited and will not help in further learning. Particularly in chemistry, there is a complex scheme of symbols, formulae and structures by rote memory. If the students are able to understand the terminology and the principle which organize the formulation of the terminology the learning would be easy and retainable.

It is high time for us to answer the question "How to learn?" in such a vast sea of knowledge properly and how we can facilitate the retrieval of the acquired concepts in some usable form at the right time. Training in innovative approaches is necessary to comprehend the material. Educational diagnosis implies the use of more or less technical procedures designed to locate specific learning and instructional difficulties, and to determine their causes. To identify the specific weaknesses in the learning of his pupils the teacher may use analysis of assignment in periodical and final examinations and also oral work in the classroom. But the more systematic way is to construct diagnostic tests and administer them for these purposes. The diagnosis of difficulties underlying educational accomplishments undoubtedly constitutes the high point in the supervisory and instructional uses of educational tests. Effective diagnostic material in any school subject can be prepared only after the skills contributing success in this field have been isolated and identified. Remedial work, accordingly, can function only when the point at which pupil mastery breaks down has been isolated.

The analysis of diagnostic test results is useful to the teacher to identify the difficulties of the students before they are firmly rooted in the students thinking and important learning points that carry over into other sections of the work can be clarified and reinforced. The new educational policy (1986) suggested measures to redesign the science curriculum so as to make it related to life. Attempts improve the quality and effectiveness of teaching and learning in schools must look into the understanding of what teachers and students do in classrooms. The learning experiences provided by the teachers also influences the quality of learning. Good teaching includes teaching students How to learn? How to remember? How to think? and How to motivate themselves? The process of teaching must be suitable to develop various individual capabilities in students and will pave the way for meaningful learning.

The exact nature of a child's learning difficulties must be revealed before it is possible to undertake remedial teaching materials. The more specific the learning difficulties information revealed, the more exactly the remedial material can be developed to fit the need. Tests as such are incapable of improving instruction. Remedial teaching is the result of deliberate constructive efforts by the teacher after the particular points of weakness in the instruction of the pupils have been revealed by the tests. On the basis of the identified factors suitable remedial teaching-learning materials must be developed for solving the problem and difficulties encountered by the students in learning chemistry.

1.2.0 EMERGENCE OF THE PROBLEM

Chemistry is one of the most important branches of science; it enables learners to understand what happened around them. Because chemistry topics are generally related to or based on the structure of matter, chemistry proves a difficult subject for many students. Chemistry curricula commonly incorporate many abstract concepts, which are central to further learning in both chemistry and other sciences (Taber, 2002). These abstract concepts are important because further chemistry/science concepts or theories cannot be easily understood if these underpinning concepts are not sufficiently grasped by the student (Zoller, 1990; Nakhleh, 1992; Ayas & Demirbaş, 1997; Coll & Treagust, 2001a; Nicoll, 2001). The abstract nature of chemistry along with other content learning difficulties (e.g. the mathematical nature of much chemistry) means that chemistry classes require a high-level skill set (Fensham, 1988; Zoller, 1990; Taber, 2002). At the beginning of any course, students start their study with a set of beliefs about the nature of

learning and what they intend to achieve (Biggs & Moore, 1993). These beliefs are derived from earlier school and learning experiences as well as their current goals and motives. An understanding of how students learn can help teachers to devise effective strategies for teaching. This requires that research into the learning process is made accessible (Clow, 1998). To facilitate the development of students' views of knowledge, students need to be supported at the appropriate level. A student, who strongly believes that there is only one correct answer, will find an exercise, which shows a multiplicity of possible interpretations confusing and unhelpful.

Numerous reports support the view that the interplay between macroscopic and microscopic worlds is a source of difficulty for many chemistry learners. Examples include the mole concept (Gilbert & Watts, 1983), atomic structure (Zoller, 1990; Harrison & Treagust, 1996), kinetic theory (Abraham *et al*., 1992; Stavy, 1995; Taylor & Coll, 1997), thermodynamics (Abraham *et al*., 1992; Özmen & Ayas, 2003), electrochemistry (Garnett & Treagust, 1992; Sanger & Greenbowe, 1997), chemical change and reactivity (Zoller, 1990; Abraham *et al*., 1992), balancing redox equations and stereochemistry (Zoller, 1990), chemical bonding (Peterson & Treagust, 1989; Taber, 2002; Taber & Coll, 2003; Coll & Treagust, 2003; Özmen, 2004; Ünal *et al*., 2006), solution chemistry (Ravialo, 2001; Goodwin, 2002; Pınarbaş, & Canpolat, 2003; Çalık *et al.*, 2005, 2006), covalent bonding (Treagust, 1988; Peterson & Treagust, 1989; Peterson *et al*., 1989; Boo, 1998;) chemical bonds and energetic (Boo, 1998; Barker & Millar, 2000), use of anthropomorphic language and analogies (Harrison & Treagust, 2000; Coll & Treagust, 2001a; Eshach & Garik, 2001; Nicoll, 2001), mental models (Coll & Treagust, 2001a, b, 2003; Coll & Taylor, 2002; Taber, 2002) and enhancing students' conceptual understanding (Barker & Millar, 2000; Harrison & Treagust, 2000).

Chemistry, by its very nature, is highly conceptual. While much can be acquired by rote learning (this often being reflected by efficient recall in examination questions), real understanding demands the bringing together of conceptual understandings in a meaningful way. Thus, while students show some evidence of learning and understanding in examination papers, researchers find evidence of misconceptions, rote learning, and of certain areas of basic chemistry which are still not understood even at degree-level (Johnstone, 1984; Bodner, 1991): What is taught is not always what is learned. To make the material easier for recall, learners actively need to construct, organize, and structure internal connections that hold the information together. The systematic

organization of knowledge, which may be considered to be the ordering of the component knowledge items in a logical, coherent, concise, and principle-based manner, is of fundamental importance for the effective learning, recall, manipulation, and use of knowledge. Salvaratnam (1993) found that effectiveness of knowledge organization is increased if the:

(i) Knowledge stored in memory is principle/concept based, coherent, systematic and concise.

(ii) Organization is around the minimum amount of essential knowledge (number of principles and concepts).

Salvaratnam (1993) also listed five aspects, which would aid the learning, understanding, recalling, and application of knowledge:

(1) Use the underlying principles and concepts as the sole basis for knowledge organization;

(2) Exclude unnecessary laws, concepts, definitions, and terms;

(3) Use systematic and meaningful terms and definitions;

(4) Link the component items of knowledge sharply and coherently; and

(5) Store knowledge concisely.

These ways could help to reduce memory overload, aid learning and understanding, and avoid mistakes. In this complexity and because knowledge construction is not easy, students often are tempted to engage in rote learning rather than meaningful learning. The teachers' task is to try to find ways to increase meaningful learning, possibly by actively involving students in the process of knowledge construction (Novak and Gowin, 1984). They suggest that it is useful to empower students to become responsible for their own learning. Learners need to decide on the level of complexity at which they will process new information. For example, a student can take notes and either writes them as key words or makes connections between this information and the previous knowledge (Su, 1991).

Some of the main findings from researches over the past few decades, attempting to establish some key general principles which may be of value in curriculum development, policy makers, teachers, teaching strategies as well as in the generation of more research work. An examination of the aims of each study will reveal the motive of the researchers who undertakes the study. Because the foundation for student conception research is the nature of learning, teachers will be able to easily translate the methods used for research into classroom practice.

The focus questions for this research are:

1. What are the main areas of learning difficulty?

2. What are the main aspects of reducing learning difficulties?

1.3.0 JUSTIFICATION OF THE PROBLEM

Chemistry learning requires much intellectual thought and discernment because the content is replete with many abstract concepts. Concepts such as dissolution, particulate nature of matter, and chemical bonding are fundamental to learning chemistry (Abraham *et al*., 1992, 1994; Nakhleh, 1992). Unless these fundamentals are understood, topics including reaction rate, acids and bases, electrochemistry, chemical equilibrium, and solution chemistry become arduous. Therefore, inquiring into students' conceptions of the fundamental concepts in chemistry has been a research focus of several researchers in many countries for the last two decades (Stavy, 1988; Peterson & Treagust, 1989; Ebenezer & Gaskell, 1995; Quiles-Pardo & Solaz-Portoles, 1995; Ayas & Demirbaş, 1997; Ayas & Coştu, 2002; Çalık *et al*., 2005). Real understanding requires not only the grasp of key concepts but also the establishment of meaningful links to bring the concepts into a coherent whole. Ausubel's important work (1968) has laid the basis for understanding how meaningful learning can occur in terms of the importance of being able to link new knowledge on to the network of concepts, which already exist in the learner's mind. Concepts develop as new ideas are linked together and the learner does not always correctly make such links. This may well lead to misconceptions. Conceptions or pieces of intellectual thought either reinforce each other or act as barrier for further learning. To overcome obstacles in learning, student conception researchers have been focusing on identifying and assessing students' "misconceptions" (Helm, 1980), "alternative frameworks" (Driver, 1981), "children's science" (Gilbert *et al*., 1982), or "preconceptions" (Novak, 1977). These labels are attached when students' conceptions are different from the scientific ideas and explanations (Nakhleh, 1992; Taber, 2000; Nicoll, 2001; Ayas, Köse and Taş, 2002).

There have been an enormous number of studies on misconceptions in chemistry and there are several reviews of this area (Anderson, 1990; Stavy, 1991, 1995; Nakhleh, 1992; Gabel & Bunce, 1994; Wandersee *et al.*, 1994). In addition, various studies indicate that student' difficulties in learning science concepts may be due to the teachers' lack of knowledge regarding students' prior understanding of concepts (Driver & Easley, 1978; McDermott, 1984). Bodner (1986) makes a salutary point when he notes that, 'We can teach - and teach well - without having the students learn". Alternative conceptions may not be just students' fault. Chemical

knowledge structures, for example, in "combustion," "physical and chemical change," and "dissolving and solutions" by their very nature lead to alternative conceptions argues Griffiths (1994). Students' conceptions are constrained both by the perceiver (learner) and the perceived (chemical phenomena) (Ebenezer, 1991). Thus, learning involves knowledge that needs to be restructured, adapted, rejected, and even discarded (Duschl and Osborne, 2002). Various other studies have focused on students' concepts and their inter-connections. Fensham and George (1973) investigated problems arising from the learning of organic chemistry while Kellett and Johnstone (1974) indicated that students had little conceptual understanding of functional groups and their role. This caused difficulties with, for example, esterification, condensation, and hydrolysis. Kempa and Nicholls (1983) found that problem-solving ability, above the algorithm level, depends on the strength of concept interlinking in a student's mind. They also found that a student's ability was dependent on context, such that individual students can do well in some areas and badly in others. Bodner (1991) has listed several factors that may lead to misconceptions in the minds of learners. He notes the problems of rote learning where students possess knowledge without understanding. When the teacher first introduces an idea, the learner may already possess previous experience (derived from the world around, including the media), which leads to confusion. In addition, there is also the problem where the scientific language remains constant while the meanings of the terms change until they become misleading. Many research tools appear in the literature to identify students' misconceptions. Examples include the diagnostic tests developed by Treagust (1988) and Krishnan and Howe (1994).

While the literature is replete with papers, which provide evidence of misconceptions, fewer papers suggest potential remedies. It is worth recognizing that misconceptions will occur - learner does not come to chemistry with empty minds. The process of learning chemistry will involve the modification or alteration of previously held ideas and this is a natural process. It is individual in nature and there is no way by which the teacher has the time or capacity to approach each learner on an individual basis. However, in practice, if concepts are developed with care, building on the language and thought forms already present, while allowing concepts to be approached from several directions, the learner will be enabled to develop ideas more meaningfully. In addition, learners need the opportunity to "play with ideas', to share ideas, to verbalize concepts so that, in a natural, step-wise fashion, concepts steadily move forward on a secure base. This will allow inadequate conceptions to be modified in an acceptable way.

Nonetheless, misconceptions will always occur, even among those highly experienced in chemistry. The whole area of misconceptions (including alternative frameworks and the ideas in Constructivism) probably needs some re-thinking. It appears to be a natural part of the developmental process and it appears to be individually idiosyncratic. However, strategies can be adopted to take advantage of this natural process in the development of more secure concept understandings. A useful future line of research might be to explore the effects of strategies, which teachers might use to take advantage of this natural process in order to give the learners an enriched understanding of important concepts. Group work, dialogue and the exchange of ideas may all be very important in allowing misconceptions to be corrected effectively.

1.4.0 STATEMENT OF THE PROBLEM

Developing and Testing the Effectiveness of Remedial Teaching Material based on Concept Formation in Chemistry at the secondary level

1.5.0 TERMS USED IN THE PROBLEM

1.5.1 CONCEPT FORMATION

Concept formation is an inductive teaching strategy that helps students form a clear understanding of a concept (or idea) through studying a small set of examples of the concept. A concept is defined by critical characteristics shared by all examples of the concept. For something to be an example of a concept, it must contain all these critical characteristics. To help students form the concept, the teacher helps them first to see these critical characteristics across different examples and, then to summarize those characteristics in a definition that students themselves write.

Concept formation also refers to a learning task in which a human or machine learner is trained to classify objects by being shown a set of example objects along with their class labels. The learner simplifies what has been observed by condensing it in the form of an example. This simplified version of what has been learned is then applied to future examples. Concept formation may be simple or complex because learning takes place over many areas. When a concept is difficult, it is less likely that the learner will be able to simplify, and therefore will be less likely to learn. Colloquially, the task is known as learning from examples.

1.5.2 REMEDIAL TEACHING MATERIALS

The materials used by the teacher for remedial teaching are referred to as Remedial Teaching Materials. Remedial Teaching is a continuous process involving testing, teaching, re-testing and re-teaching. This involves taking a student from the point where he/she is and leading him/her in the direction of greater achievement.

1.5.3 SECONDARY LEVEL

The school level following upper primary school comprising standards VII to X.

1.6.0 OBJECTIVES OF THE STUDY

(1) To identify the area of learning difficulties experienced by the students in chemistry at secondary level.

(2) To prepare a Two-Tier Diagnostic test in Chemistry to identify the nature and extent of learning difficulty experienced by the students of secondary level.

(3) To prepare Remedial Teaching Materials on those topics in which students having difficulties in chemistry.

(4) To test the effectiveness of the developed Remedial Teaching Materials by comparing the achievement in chemistry of the Treatment Groups, viz., Remedial Teaching Group (RT-using Remedial Teaching Material) and Lecture Method Group (LM-using Textual Material) for total sample in terms of:

- Pre-test Achievement
- Immediate Post-test achievement
- Delayed Memory Achievement

(5) To test the effectiveness of the developed Remedial Teaching Materials by comparing the achievement in chemistry of Remedial Teaching Group (RT-using Remedial Teaching Materials) Gender wise :

- Immediate Post-test achievement
- Delayed Memory Achievement

(6) To collect the feed-back from Secondary School Chemistry Teachers for the successful practice of Diagnostic Testing and developed Remedial Teaching Materials for students in chemistry at secondary level.

1.7.0 HYPOTHESES OF THE STUDY

H (1) When the treatment groups (Remedial Teaching Group-RT and Lecture Method Group-LM) are exposed to Experimental teaching (based on total sample), there will be significant difference among the treatment groups (RT and LM) with regard to:

- Immediate Post-test achievement scores
- Delayed Memory Achievement scores

H (2) When the Remedial Teaching Group (RT Group) is exposed to Experimental Teaching (Gender-wise):

- There will be significant difference between Boys and Girls with regard to Immediate Post-test achievement and Delayed Memory Achievement

1.8.0 DELIMITATION OF THE STUDY

For the effective investigation it is essential to have defined boundaries of the research study. Therefore, the present investigation will be confined only to-

i. The syllabus of chemistry prescribed by the U.P. Board of Education for class IX as a compulsory subject for all the secondary students.
ii. The experimental part of the study will be limited only Secondary Schools of Agra district.
iii. The Remedial Teaching Materials will be prepared only for those topics of chemistry in which students having the learning difficulties.
iv. 80 male and female students of class IX.

1.9.0 VARIABLES OF THE STUDY

As per description made above the variables of the present investigation are as under-

Independent Variable: Remedial teaching materials of chemistry

Dependent Variable: Learning Performance or Scholastic achievement of the students in chemistry

Control or Extraneous Variables: Age, sex, study subjects, contents of chemistry, curriculum, time of conducting the experiment, teacher, teaching duration, test and examination (Pre-test and Post-test)

In the investigation, all the above cited control or extraneous variables will be controlled during the experimentation by using method of constant and method of selection.

1.10.0 PROCEDURE OF THE STUDY

The present study will be carried out in two broad phases further divided into sub phases, the following procedure will be adopted in order to achieve the objectives of the study and to test the hypotheses under investigation.

Phase-1: (The Development Phase) In this phase the following steps will be followed in the procedure:

i. To explore the chemistry syllabus of class IX prescribed by the U.P. board of secondary education.
ii. Development of Diagnostic test of Chemistry.
iii. Standardization of developed diagnostic test.
iv. Development of the concept formation based remedial teaching material: The researcher will develop concept formation based remedial teaching materials for imparting the knowledge or right concepts on that topics which they find difficult and developing concept formation skills of class IX students.
v. The reliability and validity of the developed remedial teaching material will also be determined by taking the help of subject experts and by using the appropriate statistical techniques.
vi. Planning and preparation of achievement tests in the chemistry based on the units which will cover in remedial teaching during the experimentation.

Phase-2: (The Experimental Phase) In this phase the researcher will assess the effectiveness of the developed remedial teaching material based on concept formation for teaching chemistry to class IX students on their learning performance. This phase will comprise of the following sub phases:

i. Pre-test: For this the researcher will administer the diagnostic test to identify the learning difficulties areas in chemistry. Results of students' previous tests in class will also analyze.

ii. **Classroom teaching using the developed remedial teaching materials based on concept formation for four weeks:-** In this phase the researcher will teach the experimental group using the developed remedial teaching material based on concept formation for four weeks whereas the control group will be taught using the prevalent teaching-learning strategies.

iii. Post-test:- Learning performance in chemistry of both the Experimental and Control group will be evaluated using the self-developed tool.

iv. Analysis and Interpretation of the data collected: - The researcher will analyze the collected data and will interpretate on the basis of the results may obtain.

1.11.0 DESIGN OF THE STUDY

Keeping in view the nature of study, the experimental method will be used. In the present research the design of experiment will be the Pre-test post-test design. In the design, at periodic intervals an observation (measurement) will be taken to the group of IX grade students in chemistry. An experimental variable i.e. independent variable-The Remedial teaching materials will be introduced and its effect will be judged by the change or gain in learning performance in Chemistry.

GROUP	PRE-TEST	TREATMENT	SCHEDULE	POST-TEST
EXPERIMENTAL	ACHIEVEMENT CUM DIAGNOSTIC TEST	REMEDIAL TEACHING MATERIAL	4 WEEKS, 40 MINUTES PER DAY	ACHIEVEMENT TEST
CONTROL		TRADITIONAL TEACHING	4 WEEKS, 40 MINUTES PER DAY	

1.12.0 SAMPLING PROCEDURE

Sample required for the present study will be selected from the secondary schools of Agra district.

- Selection of the institution:- **Purposive method**
- Selection of the students :- **Simple Random method (80 students)**

1.13.0 TOOLS OF THE STUDY

Self- developed tools will be used by the researcher for the following purposes.

i. Pre-test (diagnostic test) to identify the learning difficulties in chemistry at secondary level.
ii. Post-test (achievement test) to evaluating the learning performance of the students.

1.14.0 STATISTICAL TECHNIQUE

In order to test the research hypotheses and to have the authentic conclusion, the following descriptive as well as inferential statistical techniques will be used-

1.14.1 DESCRIPTIVE STATISTICS

I. To describe the status of students in chemistry on the various psychological tests and on previous chemistry achievement the following descriptive statistics will be used-
    a) Mean and Median
    b) Standard and Quartile Deviations
    c) Percentage
    d) Graphical representation

II. To establish the reliability and validity of the diagnostic tests, Remedial teaching materials of chemistry, the pearson's coefficient of correlation (r) will be used.

1.14.2 INFERENTIAL STATISTICS

To test the research hypotheses under investigation and to have significant conclusions, following inferential statistical techniques will be used.

a) Test of significance

1.15.0 SIGNIFICANCE OF THE STUDY

The present investigations will certainly lead to-

- This study will be useful for curriculum planners, educational authorities and teachers to frame suitable educational programme to make the teaching-learning process more effective and meaningful.
- Improving teachers' image and reputation of institution.

- Develop healthy and positive attitude of the students regarding chemistry as a compulsory subject of their course.
- Generate a sense of deep satisfaction in the students, teacher's administrators and parents.
- Betterment of institutional climate.
- Increase concept understanding among the students in the subject chemistry.
- Reduce anxiety among the students in chemistry.
- Increase learning performance of the IX grade students.

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